ABSTRACTS, REVIEWS, AND NOTES.

THE OUTLOOK OF METEOROLOGICAL SCIENCE.

By Sir NAPIER SHAW.

[Excerpts, presidential address "Meteorology: The Society and its Fellows," Royal Meteorological Society, Jan. 15, 1919.[1]]

THE POSITION BEFORE THE WAR.

Looking backward, we must take account of a promise of remarkable activity in all branches of meteorology. Even if there had been no war, the last five years would have been fruitful years in the development of the science. The progress of aerial navigation, already begun in 1914, promised unexampled opportunities in the comparatively new study of aerography, in addition to those which meteorologists had previously made for themselves.

THE SHOCK OF WAR AND THE REACTION.

The first effect of the war was to curtail the work of of the meteorological office, but soon the demands for more numerous and more complete observations, particularly of the upper air, brought on an activity exceeding that prior to the war. There was a strong call for more general knowledge of meteorological methods and results. Suggestions almost forgotten and new ones were applied and found so helpful that "it may be that, in the near future, no meteorological observatory will be regarded as really complete if it does not possess a cinematograph camera, a searchlight, a range finder, and a chronograph, besides a kite balloon, a gun and ammunition, and crews to use them." Also, there was realized "a need for a trained meteorologist, not for the purpose of foretelling the weather, but for making the best use of the available information."

Throughout the whole course of the war we were constantly reminded that what was standing in the way of an effective use of past experiences of weather in all parts of the world was a lack of general knowledge of the common methods of meteorological study and of the principles deduced by their aid. Until this position is secured, every letter in reply to a simple inquiry must be prefaced with an explanation of what you mean by an isotherm, an isobar, the exposure of an anemometer, and even the difference between the points of the mariner's compass and the geographical orientation, and every popular lecture must begin, and generally has to end, with a recitation of rudimentary ideas.

Great impetus was given to studies of the upper air, for "meteorologists, physicists, and mathematicians alike are agreed that the key to the meteorological situation throughout the atmosphere is the relation of the wind to the barometric pressure at the same level."

LOOKING FORWARD: THE NEED FOR METEOROLOGICAL ORGANIZATION AND A PROFESSIONAL CAREER.

After this hurried glance at the past let us look forward to the future. The first thing that we realize is that with the multiplication of meteorological services there is urgent need of proper provision for training, and for the organization of a meteorological profession which will offer a graded career to men of ability, and provide the nucleus of an establishment available for various kinds of meteorological work in any part of the world. A trained meteorologist must have an adequate knowledge of mathematics and physics; we have satisfied ourselves during the war that those qualifications are indispensable, but they are not in themselves enough; there must be added to them a penetrating acquaintance with the facts of meteorology and the way in which they are obtained, as well as a knowledge of the principles of the science and its applications.

THE PRELIMINARY TRAINING REQUIRED FOR A PROFESSIONAL CAREER.

Here perhaps it is desirable to make it clear that the practice of the science of meteorology includes the process of observing, of the first part; the compilation and summarizing, in maps or otherwise, of the facts of weather, of the second part; the application of meteorological principles, which includes the forecasting of future weather, of the third part; and the development of the science of meteorology, of the fourth part. Any one of the first three may be pursued according to recognized canons of procedure with satisfactory results; every one of them is indispensable, and history is my witness that all three of them may be pursued simultaneously without any effective recognition of the fourth part, which forms our only avenue to the comprehension of the secrets of the sequence of weather.

There is no doubt that the processes of weather are simply examples of the dynamics and physics of the atmosphere, and though special methods may be required for the special problems with which we have to deal, yet the ultimate object of all our observations and all our summarizing is to lead up to an insight into the physical processes which constitute the changes in our weather; all our forecasting is the anticipation of the results of these changes. The method of forecasting by empirical rules and experience is simply a stage in the classification of the physical processes. It leads, as we know, to excellent results in the hands of experienced practitioners. It can be acquired by persons of ordinary education, but its capacity is limited, and the limit is very soon reached. To carry it further, or to make out the true inwardness of its application in special cases, we must depend upon our knowledge of the dynamics and physics of the atmosphere. Sometimes we see it suggested that additional observations of some element or other in the free air will relieve us of the arduous task of making out the dynamical process, but it is not in the least likely that we can be saved in that way from using our brains. Each new fact throws new light upon the general problem, but at the same time it generally introduces a new element of complexity. It helps toward order, but not toward simplicity. Whenever a new observation is introduced or a new instrument devised, instinctively, as our forebears have done from time immemorial, we turn to see whether it will not give us "a sign." Regretfully, I confess that in my experience the hope has always been disappointed. Take, for ex-

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ample, the differences in the times of occurrence of phenomena in the upper air and on the surface; it would be such an easy way of knowing what is coming if changes announced themselves in advance to the aeroplane or the kite balloon, but in most of the cases which I have seen the surface has been the forerunner. You are doubtless aware that a motion of the clouds from the northwest above a southwesterly wind at the surface is a common sign of an advancing depression probably bringing gales; but, rightly read, the omen, the sign of the coming gale, is the southwesterly wind which has already arrived at the surface; the northwesterly wind above it is not a part of things to come—just the reverse—it is the survival of an old depression that has gone by. The backing wind at the surface is the first sign of the coming storm, and it may appear while the pressure is still controlled by the depression that is passing away and which is still most clearly marked by the northwester aloft.

In the present position of meteorological science there are two extremes of opinion—either to think the penetration into the secrets of the subject to be so difficult that we must be content to forego the attempt and deal with what we have, as the Nautical Almanac Office, in vastly more favorable circumstances, deals with the heavenly bodies; or to think it so easy that only observations are required and the training of our brains is of no account. Both these extremes ought to be avoided. Brains without observations are certainly of no avail at all; and observations, however numerous and however widely distributed, will not at this stage of meteorlogical science exonerate us from the use of highly trained intelligence.

So if we would profit by the lessons which this war has taught us regarding the importance of the study of weather we must see to it that the whole scheme of meteorological observation and working is guided by trained intelligence. And if trained intelligence is to be devoted to the important questions which fall within the scope of meteorology there must be money to pay for it at the rates which prevail in the professions with which meteorology must in practice compete.

OFFICIAL APPOINTMENTS AND PROFESSORIAL APPOINTMENTS.

Provision of two kinds is necessary: First, a sufficient number of properly paid professional appointments in connection with the official services to afford the necessary opportunity of a professional career; and secondly, the provision for the necessary training at the universities in mathematics and physics and in meteorological principles and methods. Meteorology, like terrestrial magnetism, geodesics, seismology, and other branches of geophysics, is a graduate study, and it joins on like those to geography and geology, as well as to physics and mathematics. So far as the development of meteorology is concerned, in the matter of training there is and there can be no effective substitute for the professor and his class of students. They have a freedom for making ventures which is denied to public services. What would be regarded as a waste of public money for the professional staff of an office in the pressure of its multifarious duties is a stimulating exercise of the utmost value for a class of students.

Though the profession can not be large enough to form at each of our universities a class of students, all of whom look to the subject for a livelihood, there is no necessity on that ground for having no teachers of professorial rank. The subject is of universal interest and has been so from the dawn of history. That alone, to say nothing of its association with geology and geography, would assure a sufficient audience for a stimulating course of lectures, and with its own appeal and its association with the geophysical subjects there would be no excuse for the highest scientific ambitions of its exponents "to rust unburnished, not to shine in use."

THE SOCIETY: ITS RELATION TO THE GENERAL METEOROLOGICAL ORGANIZATION.

What, then, is the relation of the society to such a future? If I may venture to define it, I would say that the society, as representing all the many-sided interests of meteorological study, may fairly claim the right and duty of fostering, or even of creating, the atmosphere which is necessary for the successful development which is now required.

One of the urgent questions for the future is a new home for its meetings and for its invaluable library. Its journal has enriched the literature of the science with contributions of many different kinds. That, again, is capable of development with great advantage, and in one respect the need for development is extremely urgent. Meteorology is a cooperative science in the progress of which all nations share. Its literature, all told, is probably larger and more diversified in character than that of other sciences. When we take into account the diversity of language and of form, I suppose that there is no meteorologist who can follow for himself without the aid of many colleagues the progress of the science in different parts of the world; and that makes it all the more necessary for the fellows of the society to come to the assistance of each other by providing an effective survey and summary of the work that is being done.

If meteorology is to be put upon a proper footing to discharge its multifarious duties to the public, due provision must be made for the collection of observations to give a proper survey of the rainfall and other aspects of weather for all public purposes.

THE FELLOWS: THE CHANGE IN THEIR POSITION AS OBSERVERS.

Unlike the conditions in the United States, where an official organization took hold of the work of weather observations and compilations, British climatology has grown up from the associated efforts of private individuals, and only this year has passed under official control. This shifting of the control is the cause for some concern as to the direction in which the interests of the increasing number of fellows of the meteorological society can turn.

A fellow of the chemical society, the physical society, or the geological society can make chemical experiments or physical experiments or explore the geology of a locality without engaging other people to make experiments or explorations in other localities at precisely the same time and on precisely the same lines. An astronomer can observe the sun or the moon or any other of the hosts of heaven, and if, alone, he sees something which nobody else has ever observed, or sees it five minutes before another astronomer, great joy is his. With the meteorologist the matter is somehow turned the other way; every observation that he makes is unique and can not be otherwise, and yet its only guaranty of utility is that it will bear comparison with all the rest that have

gone before and with all those made under the same conditions, and at the same time, elsewhere. He is limited by a restricted routine. Official meteorology has very few words of blessing for an observer who exercises his ingenuity in devising new hours of observation, new methods of exposure, new types of common instruments, or new ways of entering observations in the "permanent register." Even improved nomenclature for the forms of clouds is apt to cause indigestion in the official interior. So, with few exceptions, every meteorological enterprise in the way of observation must be the expression of the common purpose of a number of cooperators. The simplest and easiest form of cooperation is the daily recording of a rain gage, and the next in order the daily record of a climatological station with readings once, twice, or three times a day; and the consciousness that science is dependent upon these observations for its material binds the corps of observers together with a feeling of scientific achievement. If the regular supply of observations should no longer rest upon the self-sacrifice of voluntary observers, there is some danger that the light of scientific enterprise will go out of their lives.

OBSERVATIONS ADDITIONAL TO THOSE OF ORDINARY CLIMATOLOGY.

I suppose that we have hardly yet arrived at the time when the voluntary observer can take out his aeroplane for a morning, midday, and evening stroll and get the temperatures and humidity of the upper air up to 15,000 feet as a regular thing. Those who are at all ambitious of scientific achievement might without very serious expense make an effective contribution to the study of the science by including properly tended self-recording instruments in their equipment. A full weather station of the meteorological office now includes a barograph, a thermograph, and a hygrograph. The instruments are easily procured, and except in an atmosphere like that of London they are very durable. In any circumstances their records are of astonishing interest for local purposes and of great importance in the detailed study of weather. The study of the relations of temperature and humidity to the occurrence of fog and frost in different localities is a question of immediate interest. But such instruments are scientific only if scrupulous attention is paid to setting, checking, and timing, duties which require even more skill and care than the daily readings of standard instruments. A new survey of the meteorology of the country on the basis of self-recording instruments is not unworthy of your attention.

With the exception of the sunshine recorder, self-recording instruments other than those which I have mentioned are more difficult for the observer. What an anemometer has to tell us is full of interest, but it is so much dependent upon the exposure that it is not everybody's instrument. We have, for some reason or other, not yet got the recording rain gage which we require, which will tell us truthfully when it rains and when it is not raining. The difference between rain and no rain is very important in meteorology, but a rain gage makes very little of it. It is possible and extraordinarily useful to observe the size and count the number of raindrops or of particles of dust, and to determine the quantity of water in a cloud or the amount of atmospheric pollution in the air. The few determinations of these quantities that are to be found in meteorological literature are not by any means sufficient. There are various electrical instruments, as those for solar radiation and the recording electrometer, of which there are far too few examples in operation. Perhaps the latter is not a very handy instrument in its present form, and something is required which will keep count of electrical fluctuations when thunder clouds are passing over. There is, indeed, a vast field for observations upon atmospheric electricity which is at present unexplored and is open for any one who wishes to be more enterprising than the official establishments, as may be seen by looking into Mr. W. A. D. Rudge's papers before the Royal Society. We may learn from Dr. Leonard Hill that the cooling power of air under specified conditions depending upon wind and evaporation is a very important property of the atmosphere from the hygienic point of view, and can be determined by an instrument which he calls a kata-thermometer, an ordinary thermometer which may be dry or wet and which is raised to the temperature of 100° F. and then exposed. The time which is required for a fall of 5° is read. He promises a rich reward, in the shape of scientific knowledge, for a cooperative study of the atmosphere with this instrument in different localities, and asks for observers who are willing to undertake the duty.

OTHER OPPORTUNITIES OF COOPERATION.

But observing and experimenting are only one side of meteorological activity, and here I should like to say that dealing with observations that have been made requires quite as much scientific skill and daring as devising and making the original observations. From the recollections of my correspondence at the Meteorological Office I feel sure that there are a considerable number of people with scientific aspirations in this country who regard the Meteorological Office as a collection of leisured clerks waiting to be moved to do something by the fortunate originators of bright ideas who flourish most outside, but, so to speak, within striking distance of Government institutions. I do not think I do some of my correspondents injustice if I say that the gist of the correspondence is that if they supply the ideas in the way of the design for an instrument or some original observations in the crude form the Office can do the rest. I can assure them that I have never known the staff of the office to be at a standstill for lack of ideas to carry out, and from the freedom of this chair I will be bold enough to say that there are worse services to meteorology than helping to carry out the ideas of the meteorological office.

THE SOCIETY'S LIBRARY: EPISODES OF METEOROLOGICAL HISTORY.

Let us face the situation: There are 800 of us who are interested in various ways in the study of the weather; and our common duty is, as I have said, to foster or create an atmosphere favorable for the progress of meteorology in the exceptional circumstances now before it. Our medium of communication with each other is the *Quarterly Journal*, which records for our information not only the proceedings at meetings and the papers which are contributed to it, but also the summaries of observations and of work done in various parts of the globe. The material for the advancement of the science even for the most active meteorologist lies mainly in the recorded observations of others which are contained in the library. Let me remind you again that all meteorology is cooperative, and cooperation is not limited to observing. The summarizing of observations is the first step toward utilizing them for scientific purposes, and any one who will help in that way deserves well of the Society. So does any one who will help in

the survey of the meteorological literature of other countries, which forms a large part of our collection.

There is the whole field of the history of meteorology. How little we have done to form a connected story of the study of weather as disclosed by the writings which have come down to us. Men in all ages have been face to face with the problem of the weather. How little do any of us know even of Clement Ley, of Abercromby, of FitzRoy, of Luke Howard, or of Dalton, of Piddington, or Reid, or Capper, or Loomis, or Ferrel, of Hadley, or Halley, or Hooke, or of the still earlier writers on the weather and the early observers before the invention of the barometer and the thermometer? What had the astrologers, who were prepared to forecast everything to say about the weather? Behind all the fantastic explanations which have been discarded there must have been points of view depending upon experience, which may disclose themselves in the writings which survive. What meteorological knowledge had the discoverers of America? What sort of wind blew the Norsemen to Labrador? If I have any knowledge of the feelings of the Society, it would welcome occasional contributions on the history of the science, recent or remote, not less warmly than an account of personal observations. Mr. Bentley has already told us about weather in war, and Mr. Inwards has given us the meteorology of proverb and folklore. Will not some one tell us of meteorology in literature? *Recular pour mieux sauter* is as apposite to the progress of science as to any other persistent effort, if by it we may understand that an occasional survey of the past helps us to make more sure of the future. Of the 800 of us there must be some who had more leisure and opportunity for retrospective study than the few exponents of meteorology in its modern form, upon whom the Society is accustomed to rely for its subjects of discussion.

THE FELLOW AS A CENTER OF LOCAL INFLUENCE.

And outside the immediate sphere of the Society there is much that is necessary to create an atmosphere favorable for the development of the science. We want people to know that meteorology is not exclusively forecasting. No doubt the view into the unknown future is as Prof. Schuster said in his address to the British Association, the lure of all scientific research, but the long way that has to be traveled in order to make sure of it rewards us with many side views of common human interest. The discovery of the separation of the atmosphere into troposphere and stratosphere surely belongs to the great achievements of the human intellect, and the meteorological exploration of the globe is worth reciting. So I can picture to myself a meteorologist, in some part of the Kingdom or the Empire so remote that he can not share the privileges of our monthly meetings, who would be a center of knowledge of the weather without aspiring to a reputation for foretelling the fortunes of his neighbor's hay or anticipating the prospects of a smooth passage. I admit that it is almost impossible to be the one and avoid the other, largely because meteorology which is not forecasting is a matter of books, maps, pictures, diagrams, and so on. Shortly after the armistice was signed an enterprising film maker wished to make a "movie" of the work of the meteorological office, which he understood had been of great importance in the war. I explained that he might begin with the observer at Spitzbergen or at Madeira and end up with somebody manipulating the receiver of an ordinary telephone; that the intervening parts were telegraph offices, with wires or without, and a person, not in uniform, drawing a map. Finally we came to the conclusion that meteorology would have to be specially dramatized to make a moving picture.

THE AMATEUR'S LIBRARY AND LABORATORY AS A PERMANENT DEMONSTRATION.

So it is with the meteorologist at home—his laboratory is his library, the instruments are books of tables and a slide rule, a drawing board and squared paper or an outline map. He can not even repeat the experiment of forecasting to-morrow's weather until the map comes in, made by somebody else out of other people's observations. But his maps and diagrams when they are drawn are sometimes of arresting interest. And if ever the time should come, as I hope it may, when I have the leisure to please myself as an amateur meteorologist, I for my part, as my duty to the society and for the pleasure of recalling the work of many colleagues, shall make a meteorological laboratory, and I invite other fellows to do the same. It will be mainly books, long rows of books, whose bindings are unimpressive and whose insides are repulsive masses of figures, but they will be in cases with glass doors in the frames of which will be maps and diagrams, photographs of clouds and other pictures expressive of epochs in the study of weather, that tell of notable achievement in a difficult science, that will be sufficiently interesting, in and for themselves, to stifle the almost irrepressible question, "Will it help in forecasting?" and to convey even to the casual visitor the impression that there are many things about the atmosphere that are worth knowing.

I hope that these remarks may appeal particularly to those who are concerned with the teaching of meteorology in schools and colleges, if any colleges there be in which that study finds a place. There are, I know, or there were before the war, many schools in which the practice of observation is taught, and I would like to impress upon them that, while the knowledge of how things are done in practice is important for the learner, it is the knowledge of what things have been done that provides inspiration for the future. The things that have been done in meteorology are not to be found in personal observations, but in books of very special character, which are easily obtained by those who know where to get them, but do not find their way into ordinary libraries. So the material of teaching for meteorology is a collection of special books that wants a classroom as its home and forms a special library. And the knowledge of what has been achieved is best displayed by photographs, maps, and diagrams on a larger scale than is possible in ordinary books, which should have their home on the library walls even if they hide the binding of the books. With these in sight, experience becomes knowledge, and knowledge leads to the desire for more experience.

ATMOSPHERIC PERIODICITIES.

By P. LEVINE.

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A curve is drawn showing serial values of the lowest reading of the barometer at Paris for each year from 1700 to 1918, from which it appears that there is a periodicity in this quantity of about 96 years—the curve for 1700 to 1821 being very similar to that for 1796 to 1916.—*R. C.*